

CLAIMS

1. An LED lamp comprising:

a first LED semiconductor stack (208) having at least one semiconductor layer comprising gallium and nitrogen (InGaN);

a reflector reflective to light from said first LED stack below said first LED stack and parallel to said at least one semiconductor layer; and

a second LED semiconductor stack (308) below said reflector and comprising semiconductor layers that are lattice-matched to gallium arsenide.

2. An LED lamp according to claim 1 wherein said reflector is reflective to light from said first LED stack having an angle of incidence to the reflector of 60 degrees.

3. An LED lamp according to claim 1 wherein at least one of said LED stacks includes cavities that divert light generated in the stack.

4. An LED lamp according to claim 1 wherein at least one of said LED stacks includes LED elements (E, TE) that are separated from each other by light-diverting cavities and wherein a plurality of said LED elements are interconnected for driving them in unison.

5. An LED lamp according to claim 4 wherein at least one of said LED stack acts as a light-guide core and wherein said cavities are trenches each having a width (K) greater than its depth.

6. An LED lamp according to claim 2 wherein at least one of said LED stacks includes LED elements (E, TE) that are separated from each other by light-diverting cavities and wherein a plurality of said LED elements are interconnected for driving them in unison.

7. An LED lamp according to claim 6 wherein at least said second LED stack acts as a light-guide core.

8. An LED lamp according to claim 1 wherein said reflector is of non-semiconductor material.

9. An LED lamp according to claim 1 including a heat sink below and attached to said second LED stack and including light extraction cavities in said second LED stack that have been formed after its attachment to the heat sink.

10. An LED lamp according to claim 1 wherein one of said LED stacks is attached to a member that has served as a support for that LED stack during removal of at least part of its growth substrate.

11. An LED lamp according to claim 1 wherein for at least one of said stacks the stack has light extraction cavities therein and is joined to a member that has provided support for the stack during formation of its cavities.

12. An LED lamp according to claim 1 including at least part of a growth substrate for said first LED stack.

13. An LED lamp according to claim 1 wherein for at least one of the LED stacks the stack includes an active layer region having a width and a thickness and the composition of the active region is varied in the direction of the thickness so as to substantially broaden the spectral distribution of the light generated by the region.

14. An LED lamp according to claim 1 wherein for at least one of the LED stacks the stack includes an active layer region having a width and a thickness and the composition of the active region is varied in the direction of the width.

15. An LED lamp according to claim 1 including fluorescent material that converts part of the light generated by said first LED stack into light having a color (434) lying between that produced by said first LED stack and that produced by said second LED stack.

16. An LED lamp according to claim 1 wherein said second LED stack can generate red light and said first LED stack includes an active layer that generates

green light in first portions thereof and blue light in second portions thereof, the first portions being interconnected for driving them together, and the second portions being interconnected for driving the second portions together and independently of the first portions.

17. An LED lamp according to claim 16 wherein said first portions are interleaved with said second portions, whereby the green light can be blended more effectively with the blue light.

18. An LED lamp according to claim 1 wherein at least one of said LED stacks has a hole through it via which an electrical connection is made to the other of said LED stacks.

19. An LED lamp according to claim 4 including LED elements each having a top face with an acute angle.

20. An LED lamp according to claim 1 wherein at least one of said LED stacks includes LED elements and metal links for feeding currents to the LED elements and wherein for faulty LED elements that draw more than an allowable amount of current the links for feeding the faulty elements are disrupted.

21. An LED lamp according to claim 4 wherein said reflector is transparent to light rays generated in said second LED stack incident normal to the reflector.

22. An LED lamp according to claim 2 wherein said second LED stack comprises AlGaInP.

23. An LED lamp according to claim 4 wherein said second LED stack comprises AlGaInP.

24 . An LED lamp according to claim 1 wherein said reflector includes metal.

25. An LED lamp according to claim 9 wherein said heat sink is of metal.

26. An LED lamp according to claim 4 wherein for at least one of said LED stacks the stack has first LED elements that produce light of a first color and second LED elements that produce light of a color different from said first color.

27. An LED lamp according to claim 4 wherein each of said cavities has at least one side wall through which LED light passes and has a metal cavity reflector that redirects at least part of the passed light.

28. An LED lamp according to claim 27 wherein said metal cavity reflector provides multiple reflections for a light ray from its associated side wall.

29. An LED lamp according to claim 27 wherein the metal cavity reflector serves as a current feeder for a semiconductor layer.

30. An LED lamp according to claim 27 wherein said cavity is in an LED that has had at least part of its growth substrate removed.

31. An LED lamp according to claim 4 wherein at least one of said cavities has a side wall (76) that is at least partly covered with a side-wall metal reflector.

32. An LED lamp according to claim 31 wherein the side-wall metal reflector serves as a current feeder for a semiconductor layer.

33. An LED lamp according to claim 3 wherein each of said cavities has a floor and side walls joined to the floor by fillets.

34. An LED lamp according to claim 1 including a light diverting cavity formed with the aid of a floated rotary cutter.

35. An LED lamp according to any one of claims 1, 2, 4, 6, 18, 22, 26, 27, 29 or 34 that can produce white light.

36. An LED lamp according to claim 19 that can produce white light.

37. An LED lamp according to claim 20 that can produce white light.

38. An LED lamp according to claim 4 and capable of generating white light wherein said first LED stack has first LED elements that generate green light and second LED elements that generate blue light and wherein said second stack has at least LED elements that generate red light.

39. An LED lamp according to any one of claims 1, 2, 4, 18, 22, 26, 27, 29 or 34 arranged for selectively generating red, amber and green light whereby the lamp can be used in a single-housing traffic light.

40. An LED lamp according to claim 19 arranged for selectively generating red, amber and green light for use in a traffic light.

41. An LED lamp according to claim 20 arranged for selectively generating red, amber and green light for use in a traffic light.

42. An LED lamp according to claim 4 arranged for selectively generating red, amber and green light for use in a traffic light wherein said second LED stack has first LED elements that generate red light and second LED elements that generate amber light.

43. An LED lamp comprising:

a first inorganic LED structure, having semiconductor layers;

a reflector (403) below and parallel to said layers that is reflective to light from said first LED structure;

a second inorganic LED structure positioned below said amorphous reflector; and

wherein said reflector prevents entry into said second LED structure of a substantial part of the light generated in said first LED structure.

44. An LED lamp according to claim 43 wherein said reflector is of amorphous material.

45. An LED lamp according to claim 43 wherein said first and second LED structures are joined together with metal.

46. An LED lamp according to claim 43 wherein at least one of said LED structures includes LED elements and metal links for feeding currents to the LED elements and wherein for faulty LED elements that draw more than an allowable amount of current the links for feeding the faulty elements are disrupted.